PIER Energy-Related Environmental Research
Environmental Impacts of Energy Generation, Distribution and Use

Evaluating the Impacts of Manufactured Recreation Streamflows on the Macroinvertebrate Community of a Regulated River

Contract #: 500-01-044
Contractor: Garcia and Associates (GANDA)
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The Issue

Hydroelectric licensing agreements provide that regulated rivers may experience sudden, short-term increases in streamflow (i.e., "pulsed flows") for operational, experimental, or recreational purposes. Understanding the consequences of such flow manipulations for stream biota, including the effects of relative differences in the magnitude, frequency, duration, and timing (or seasonality) of pulsed flows, is critical for regulatory decision making.

Modified Coleman-Hynes rock basket samplers used for 2004 benthic macroinvertebrate sampling in the North Fork Feather River. The sampler on the right shows the net in the retracted or "set" position. Note that the inner basket is not filled with substrate in this photo.

For example, in the North Fork Feather River (NFFR), Plumas County, California, pulsed flows are provided on a monthly basis for recreational whitewater boating during the typical low-flow (i.e., baseflow) season of summer and early fall. The magnitude of these one-day pulsed flows is typically four to seven times that of baseflow levels, and the timing of these flow events (late June through late October) is generally contrary to both the natural hydrograph for the region and the regulated hydrograph maintained under normal hydroelectric operations. High-flow periods in this system generally occur in conjunction with winter and spring storms and spring snowmelt runoff, whereas summer and early fall are typically dry.

Previous studies in the NFFR have demonstrated that recreation streamflows cause temporary increases in invertebrate drift, which in turn produce short-term differences in post-flow benthic macroinvertebrate communities.[1] However, the extent to which longer-term temporal differences

[1] Garcia and Associates (GANDA). 2005. Rock Creek-Cresta Recreation Streamflow Monitoring: North Fork Feather River, Plumas County, CA. Rock Creek-Cresta Hydroelectric Project (FERC No. 1962). *Year One Report: 2002 Macroinvertebrate Drift Sampling* and *Year Two Report: 2003 Benthic Macroinvertebrate Sampling.* Final reports prepared for Pacific Gas and Electric Company.

may be attributable to pulsed-flow treatments remains unclear. For example, seasonal declines in benthic community metrics such as richness, diversity, and abundance observed in the NFFR may result from cumulative impacts associated with repeated flow events, or simply from natural life history patterns of various invertebrate taxa. Spatial (i.e., control-impact) comparisons with an unaffected reference reach are required to understand such baseline seasonal changes, and to isolate the effects of natural vs. manufactured sources of variation in benthic community structure and composition.

Project Description

This study examined the benthic macroinvertebrate community in an upstream reference reach of the NFFR that did not experience pulsed recreation streamflows in 2004. This "control" reach was sampled concurrently with the downstream "treated" reach (section of the river experiencing pulsed flows) before and after each recreation streamflow event in 2004. Macroinvertebrate sampling followed the same representative artificial substrate (rock basket) sampling methods employed in previous studies of the treated reach, as well as standard kick-sampling techniques in both reaches. Macroinvertebrate data were described using the recently developed hydropower multi-metric index (Hydro-MMI), which was designed to be sensitive to the effects of hydropower operations. Analysis of variance (ANOVA) was used to test for a pulsed-flow effect.

The primary objectives of this study were (1) to quantify any short-term differences between the benthic community of the treated and control reaches immediately before and after pulsed recreation streamflow events; (2) to determine if longer-term seasonal trends in the benthic community of the treated reach differed from that of the control reach following repeated pulsed-flow events; and (3) to compare the efficacy of representative basket sampling vs. standard kick-sampling methods for detecting pulsed-flow-related changes.

PIER Program Objectives and Anticipated Benefits for California

This project offers numerous benefits and meets the following PIER program objective:

- **Evaluating the environmental effects of energy production and delivery.** This research directly informs regulatory decision-making processes that determine how aquatic resources are managed in California's regulated rivers. By understanding the effects of recreation streamflow releases, resource managers will be better able to balance the various economic, recreational, and environmental demands on riverine resources, and thereby provide for the widest variety of beneficial uses in conjunction with hydropower generation.

Results

The control-to-treated difference in Hydro-MMI was significantly different from pre-flow to post-flow ($p < 0.10$). Among basket-sample data, seasonal trends between these two reaches were generally similar; however, kick-sample data suggest a seasonal pattern of increasing richness and abundance in the control reach that was not observed in the treated reach.

Overall, short-term control-to-treated differences were not consistent or large enough to necessarily be considered biologically significant, even though they were statistically significant in the context of the experimental design. Conversely, longer-term seasonal differences,

especially among kick-sample data, suggest biologically significant control-to-treated differences, despite the fact that no statistical significance was detected.

Comparisons of the basket- and kick-sampling techniques demonstrated that basket samplers selected for a subset of the benthic community dominated by filter-feeding organisms such as net-spinning caddisflies. These organisms appeared able to quickly colonize and capitalize on the free interstitial spaces in the basket samplers. Kick samples provided a better representation of the overall benthic community. Differences in the composition of the two sample types suggest that seasonal trends among basket-sample data primarily followed natural seasonal patterns for the filter-feeder-dominated community that developed in basket samplers, which may be less sensitive to flow-related changes than the larger benthic community. Therefore, the research team recommends that future evaluations of pulsed recreation streamflows in the NFFR be based on direct bottom-sampling methods such as kick sampling, instead of artificial substrate sampling. Kick samples appeared to detect pulsed-flow-related disturbances better than basket samples, particularly potential cumulative effects across longer (e.g., seasonal) timescales.

The Hydro-MMI was more useful than individual metrics for both discriminating baseline control-to-treated differences and detecting pulsed-flow-related disturbances. The project team thus recommends that benthic macroinvertebrate data from future studies of pulsed-flow effects be compiled and evaluated using the Hydro-MMI.

Final Report

The final report for this project, *Evaluating the Impacts of Manufactured Recreation Streamflows on the Macroinvertebrate Community of a Regulated River* (CEC-500-2006-078), is posted on the Energy Commission website at www.energy.ca.gov/pier/final_project_reports/CEC-500-2006-078.html.

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